SIGGRAPH 2001

EXPLORE INTERACTION AND DIGITAL IMAGES

Integrating Shape and Pattern in Mammalian Models

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Overall Goal

Development of an integrated scheme for generating rich visual details for patterned animals

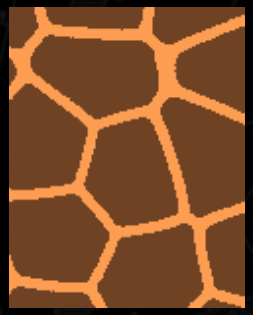
The Problem

Integration of the visual and shape elements of an object

- Usual method is to model shape, then add pattern
- Usually done with texture mapping or 3D painting

Strategy

Pattern Formation



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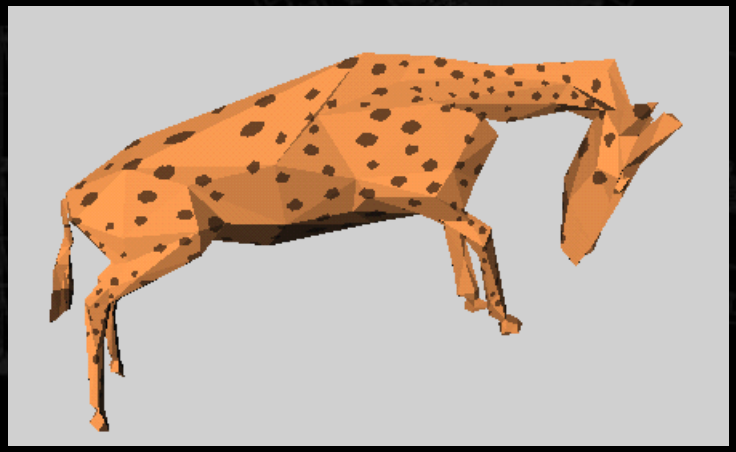
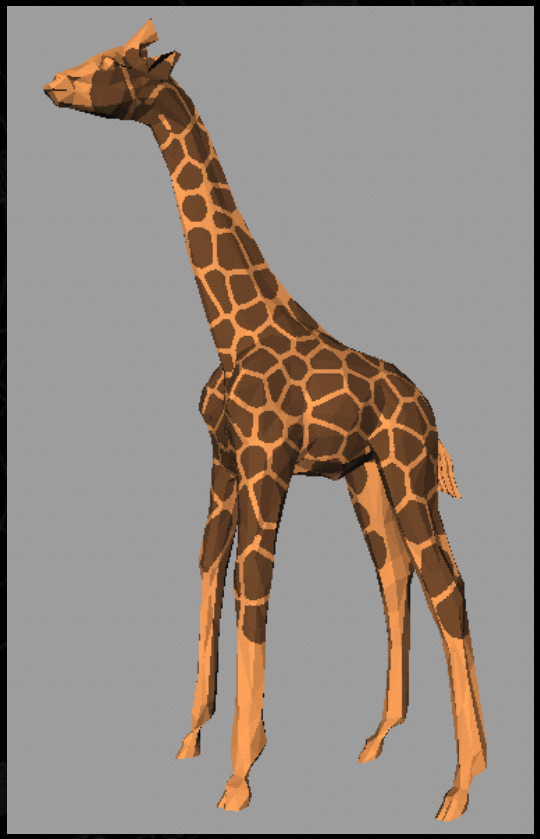
Embryo Development



Growth



Strategy

1 - Develop a method to generate patterns found in mammalian coats, especially giraffes and big cats

2 - Controlled transformation of a shape

3 - Integration of the two

Inspired by Nature itself

Previous Work

Pattern Generation

- Reaction-Diffusion (Turing'52, Murray, Bard)
- Turk'91, Witkin&Kass'91

Shape Transformation

- Beier&Neely'92, Lerios et al'95

Integration

- Turk'91, Fowler'92, Fleischer'95

1 - Clonal Mosaic Model

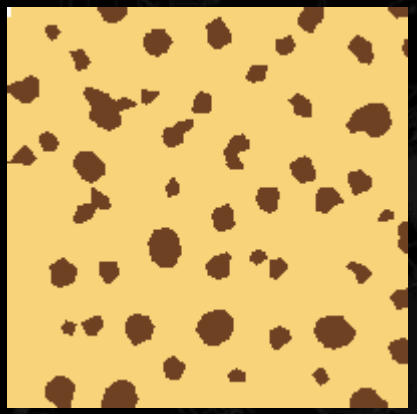
Patterns reflect an underlying arrangement of skin cells in lower layers of the epidermis

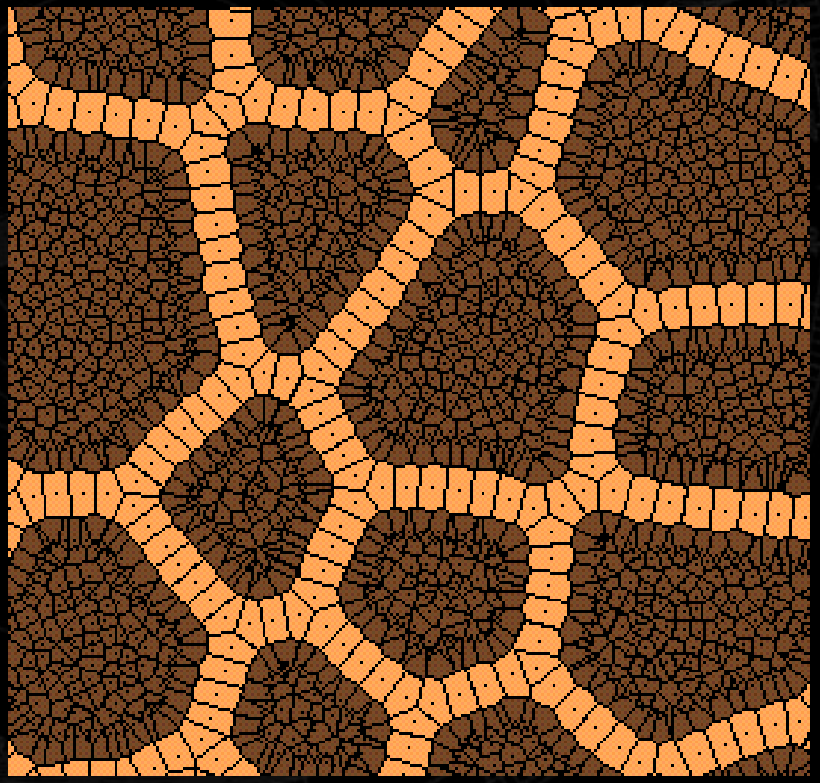
Mosaic

Each group of cells derive from a single progenitor, i.e., they are clones

Clonal

Overview of the Model





Main Parameters and their roles

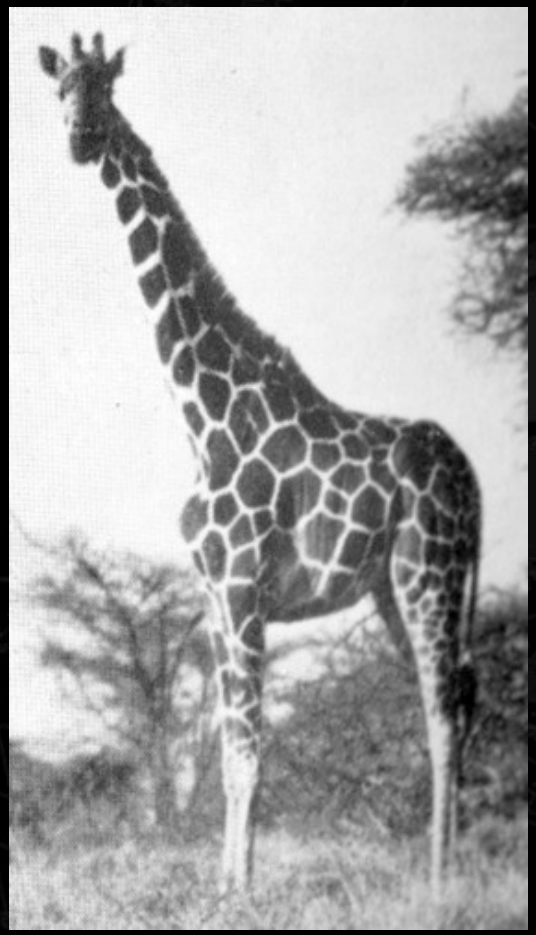
Division rate: absolute and relative numbers of cells of each type

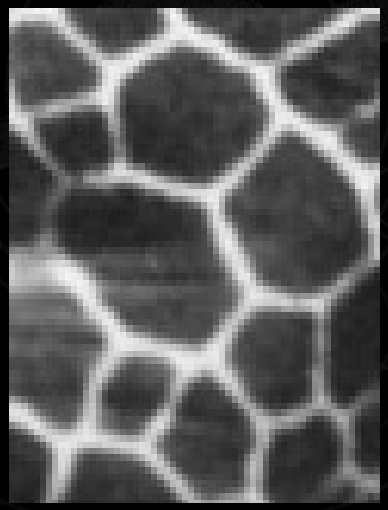
Adhesion: tendency of cells to stay together

Anisotropy: tendency of cells to move in a preferred direction

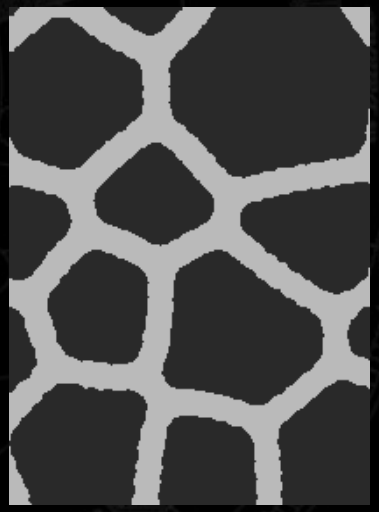
Probabilities: distribution of types of cells

Giraffe Patterns (Reticulata)





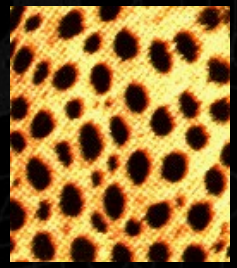
Real



Computed

Spotted Patterns

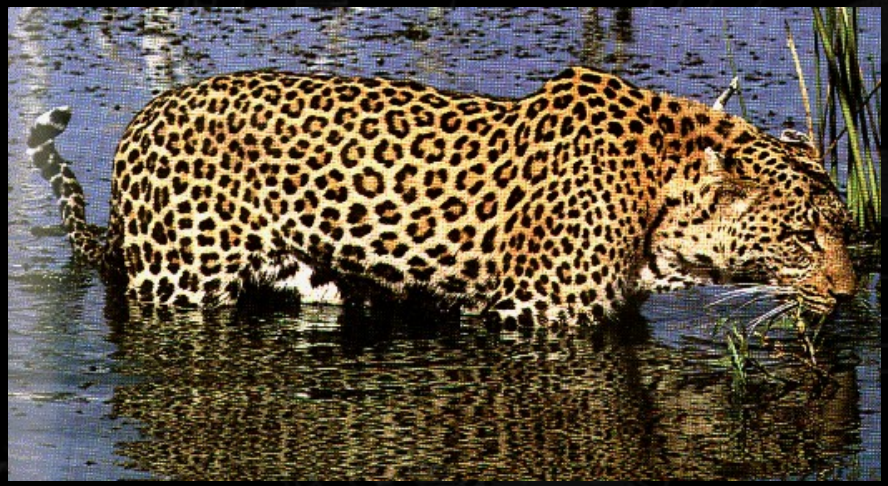
Computed



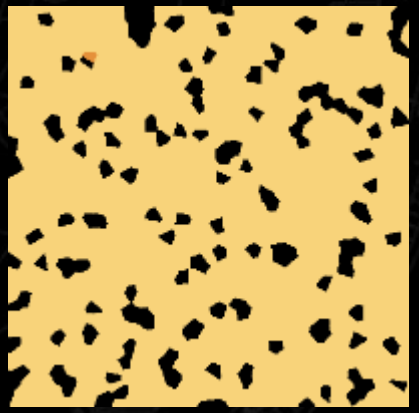
Real

Computed

Rosette



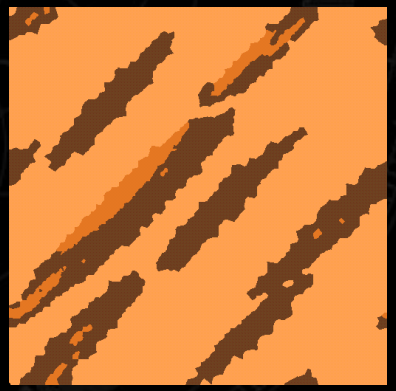
Real



Computed

Anisotropic Patterns

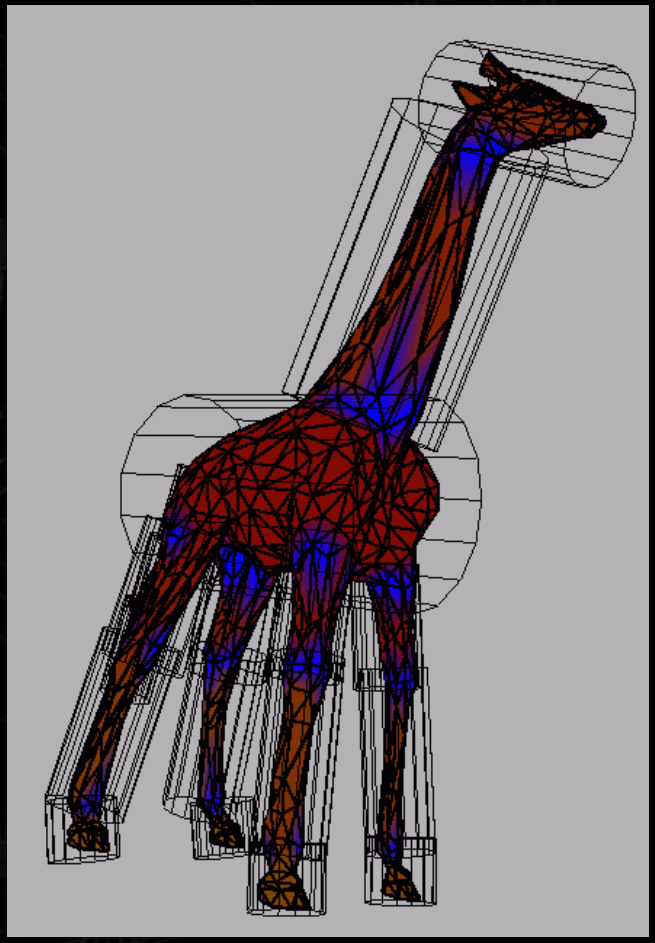
Computed



Computed

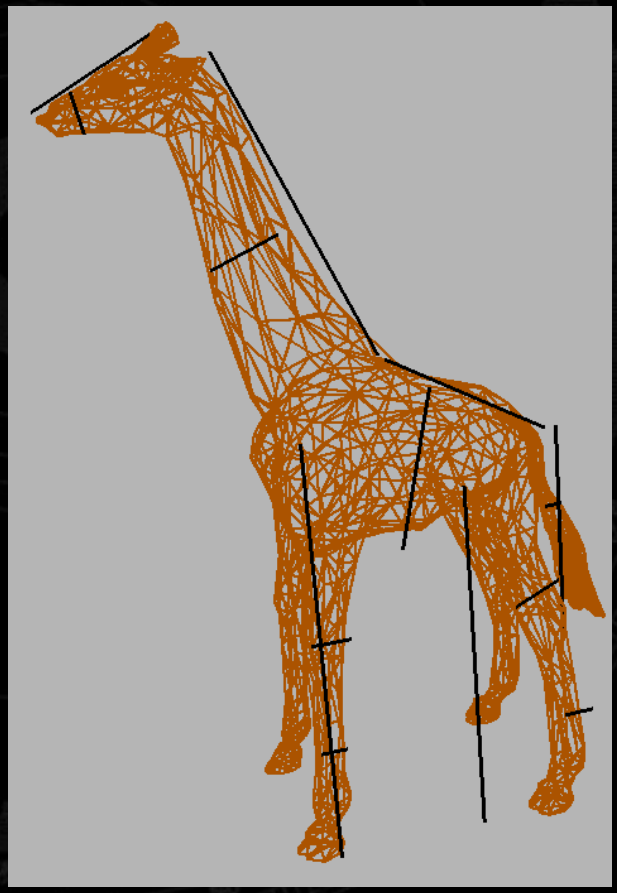
2 - Controlled Shape Transformation

- Set of primitives defines a hierarchical structure. Ancestry is defined by the user
- Overlap of primitives: continuity and smoothness
- Primitives are cylinders

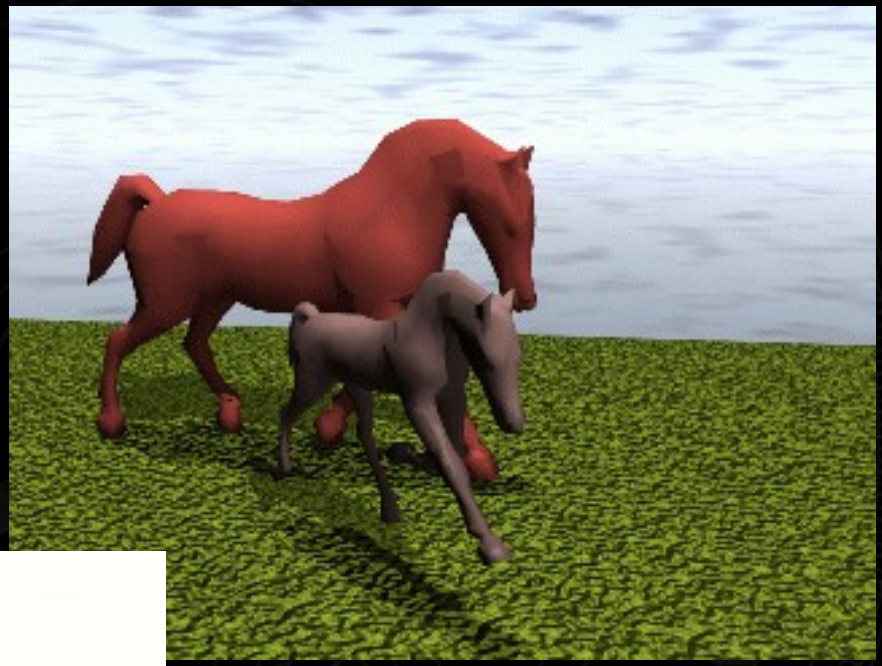


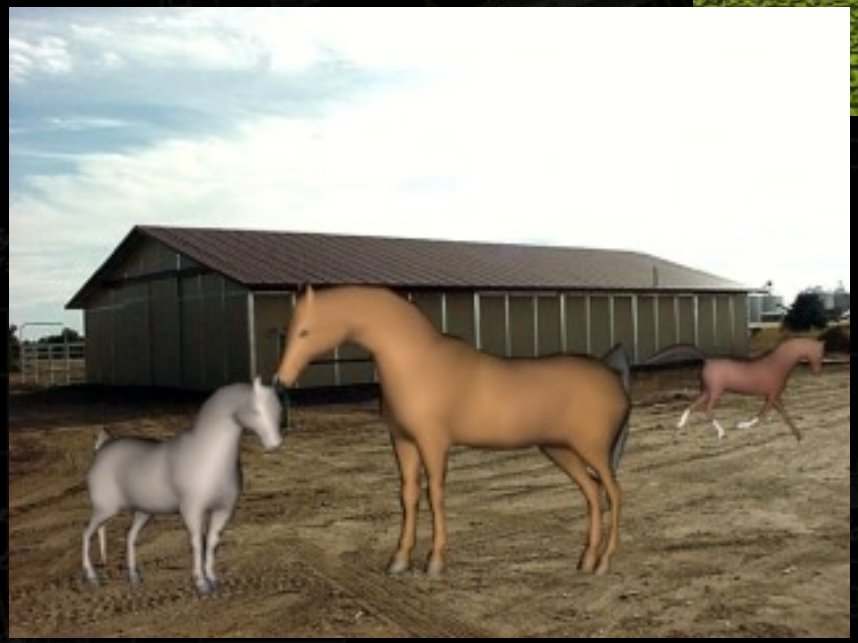
Controlled Shape Transformation

- Set of features drives the transformation
- Position and size of features match real measurements



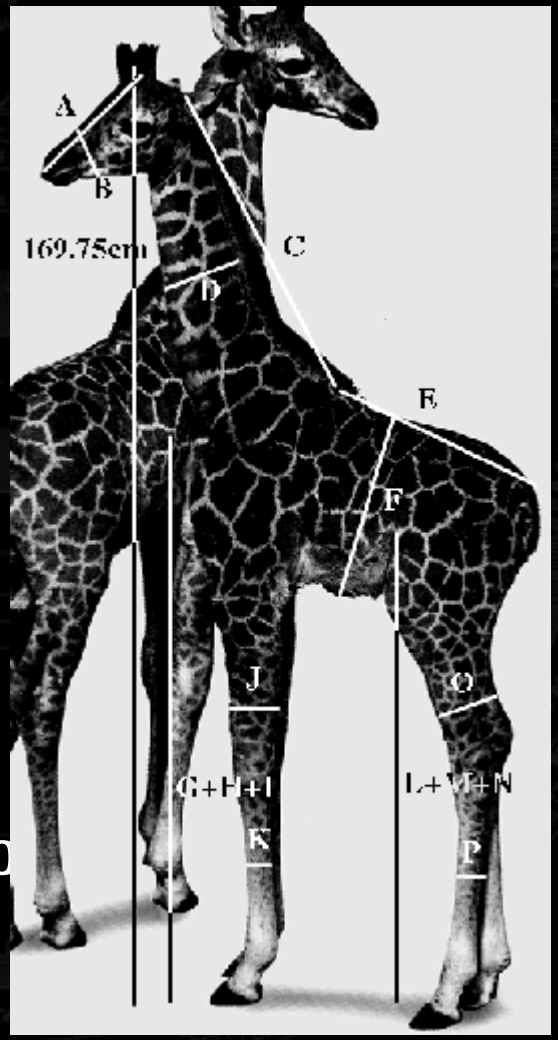
Examples

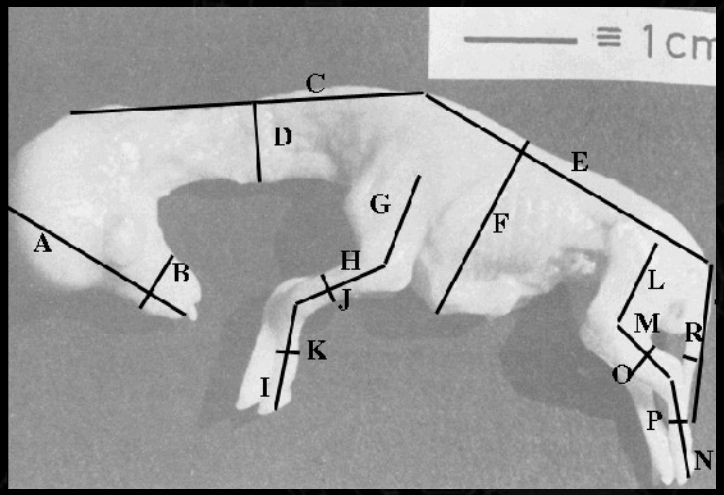




Obtaining Real Measurements

Newborn giraffe





35-45 days giraffe embryo

3 - Integration

Simulate the CM model directly on the surface of geometrical models

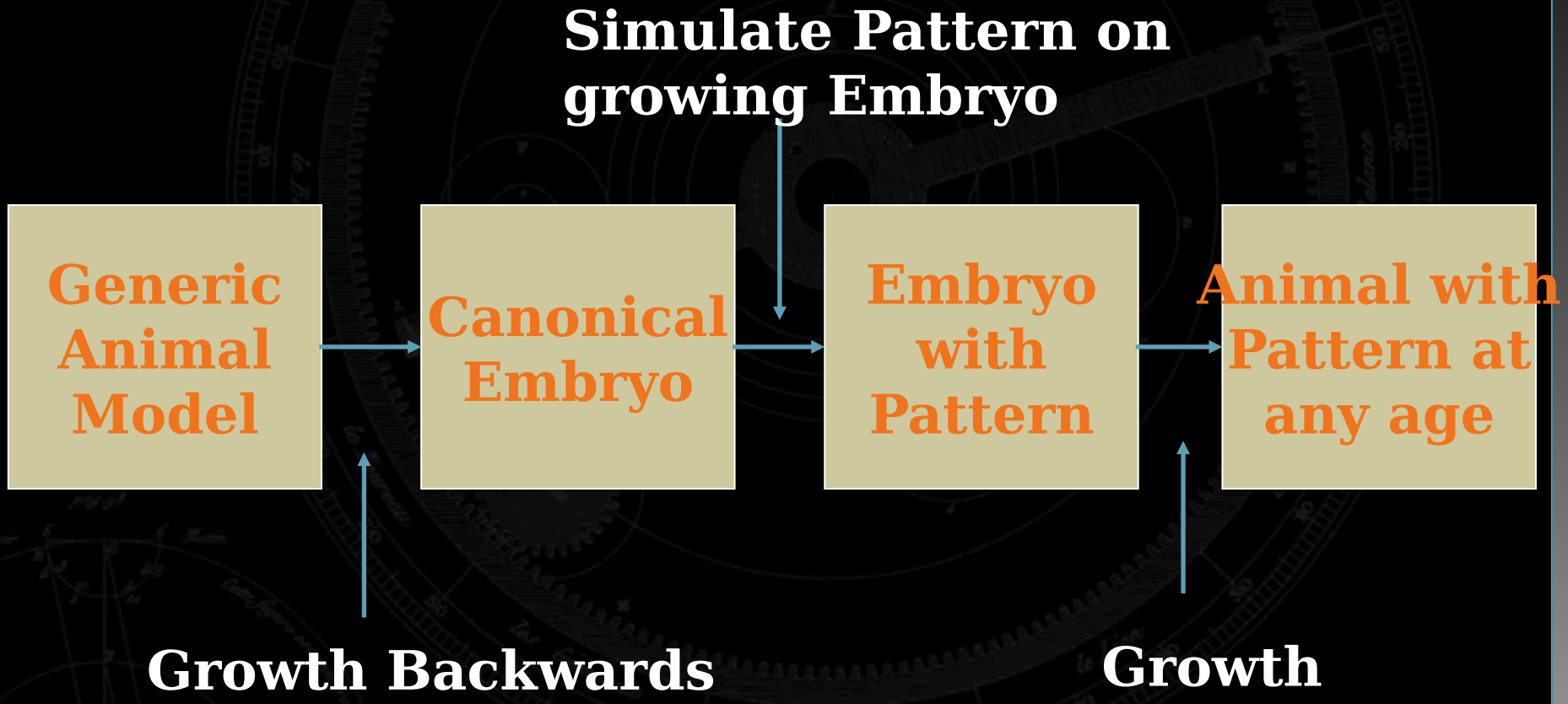
Three possibilities

- Generate pattern on a fixed geometry
- Change geometry and keep pattern
- Develop pattern on a changing geometry

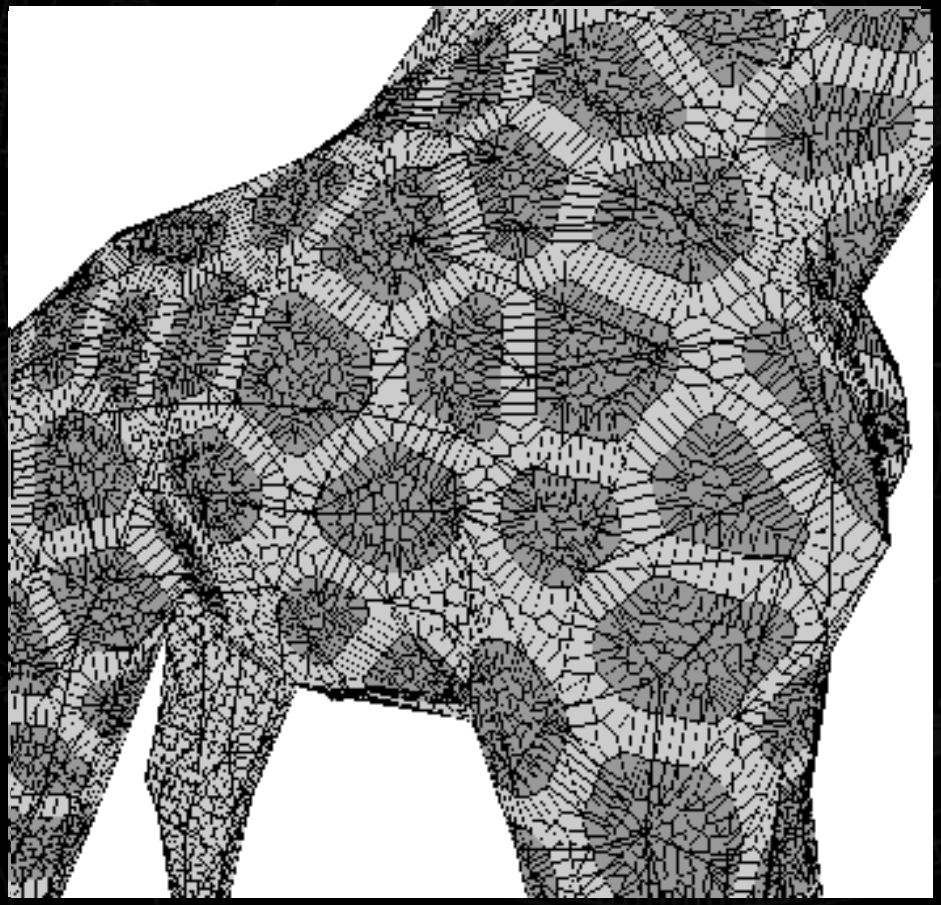
Integration Factor

Compute splitting rates from growth information

Schematic Representation

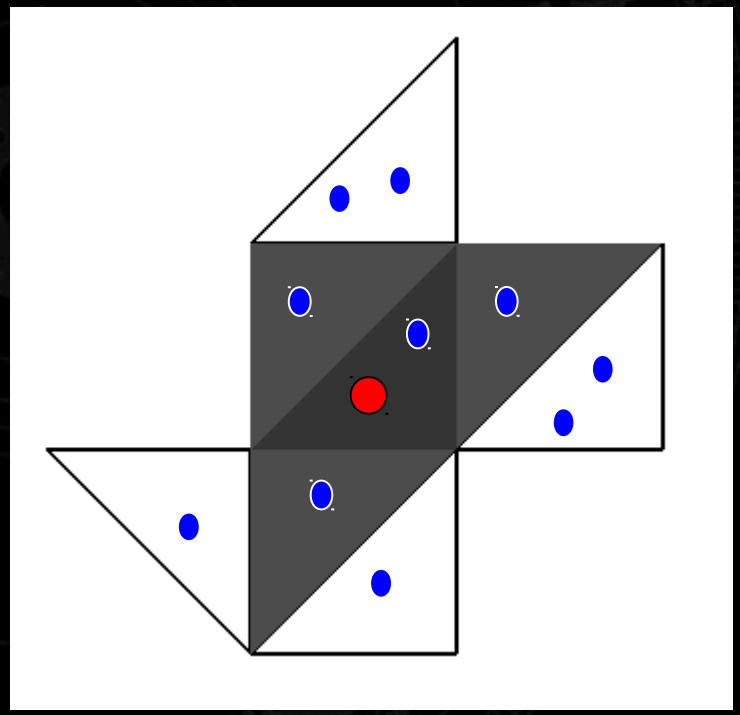


Pattern on the Surface

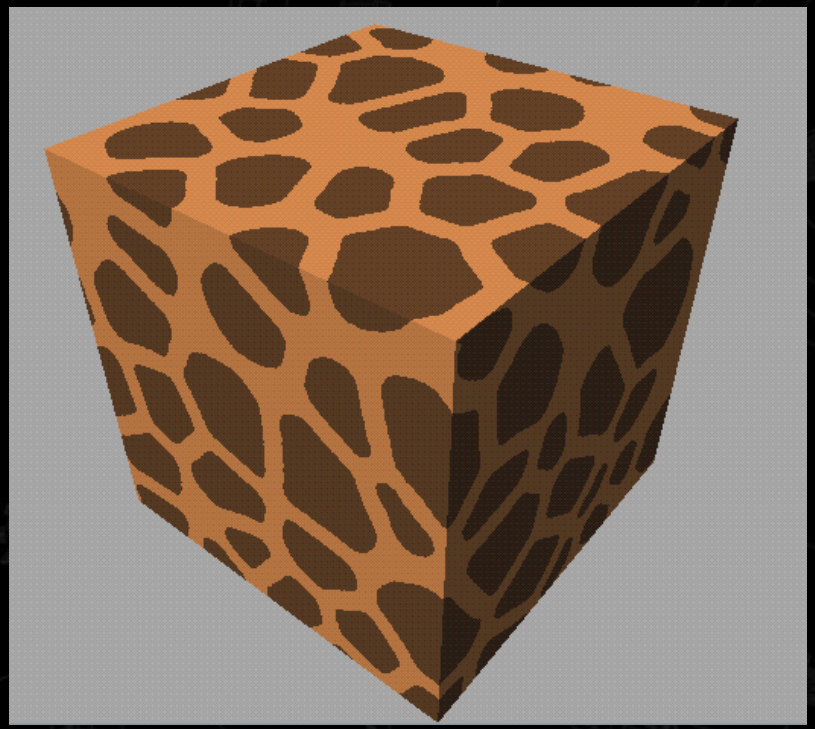


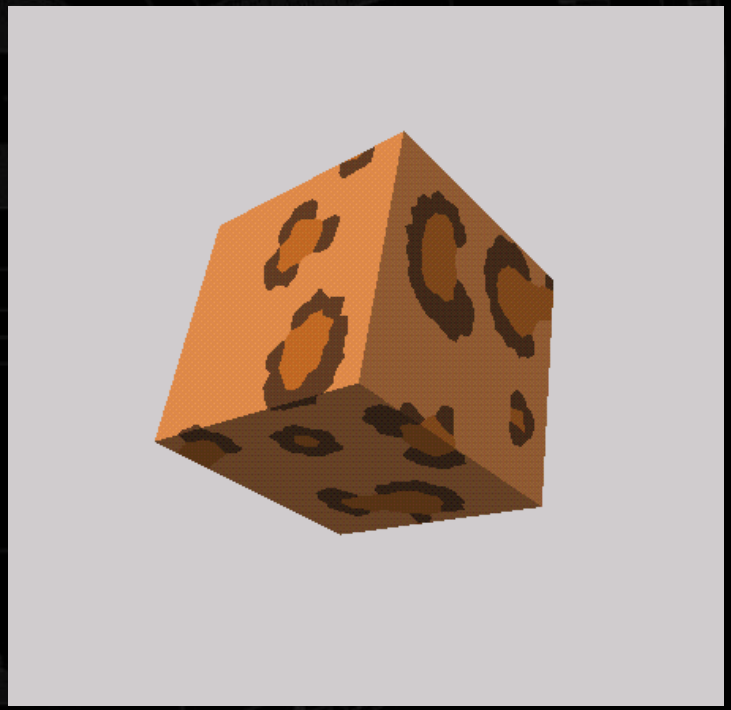
From 2D to 3D

- Distribution of random points on the surface
- Deriving Cell Splitting Rates from Growth Information
- Relaxation and computation of the Voronoi diagram on the surface

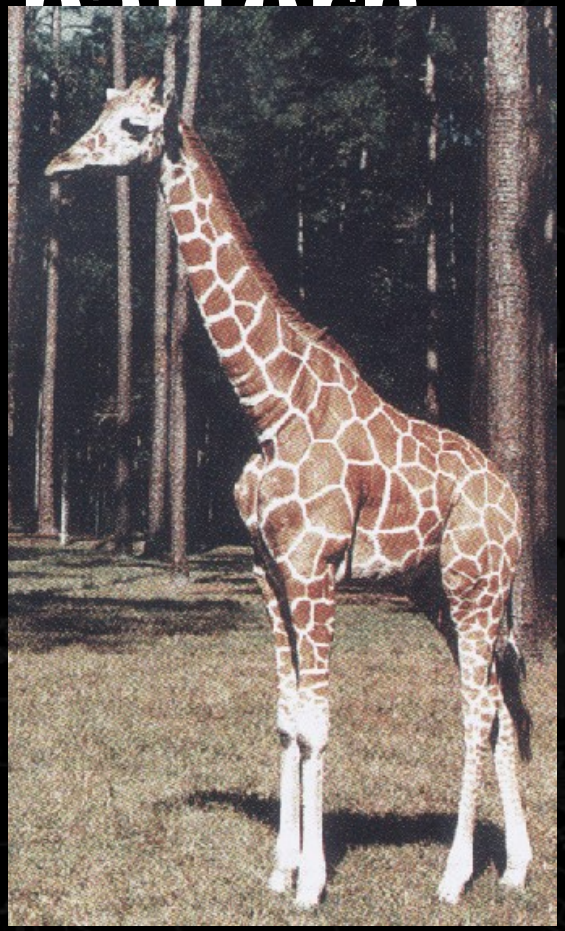


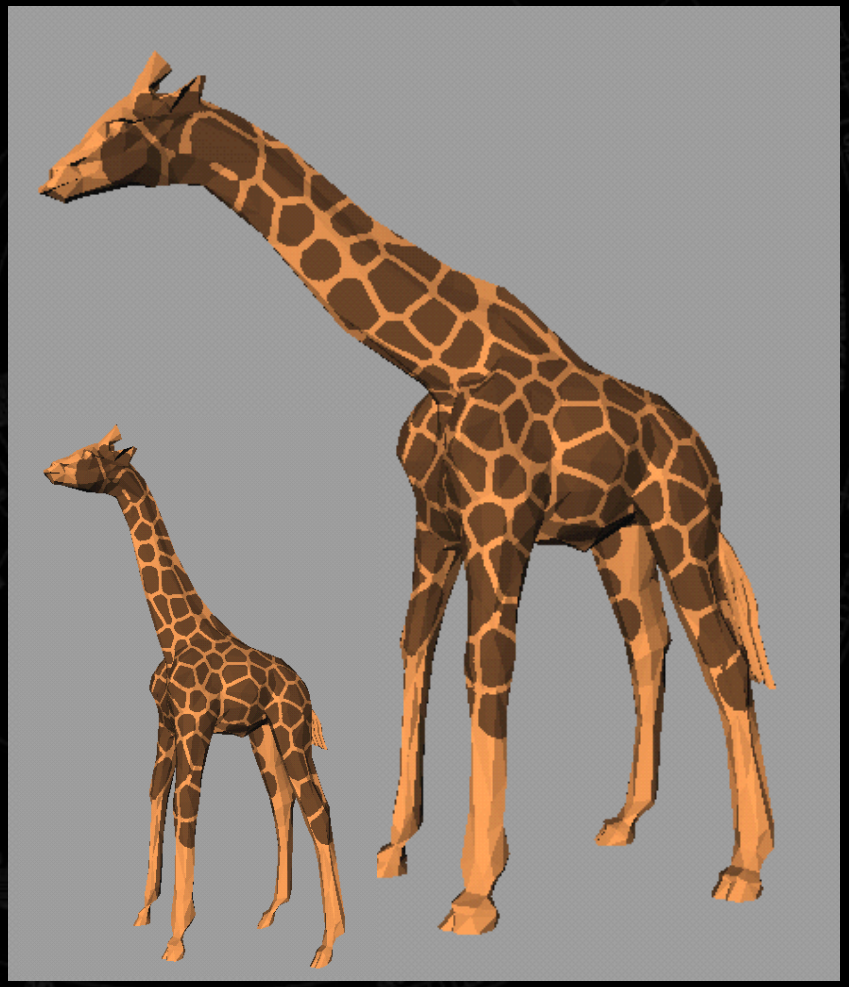
Pattern on a fixed geometry (without growth)





Change geometry and keep pattern





Develop pattern on a changing geometry

(not in scale)

Develop pattern on a changing geometry

(not in scale)

Develop pattern on a changing geometry

(not in scale)

Develop pattern on a changing geometry

(not in scale)

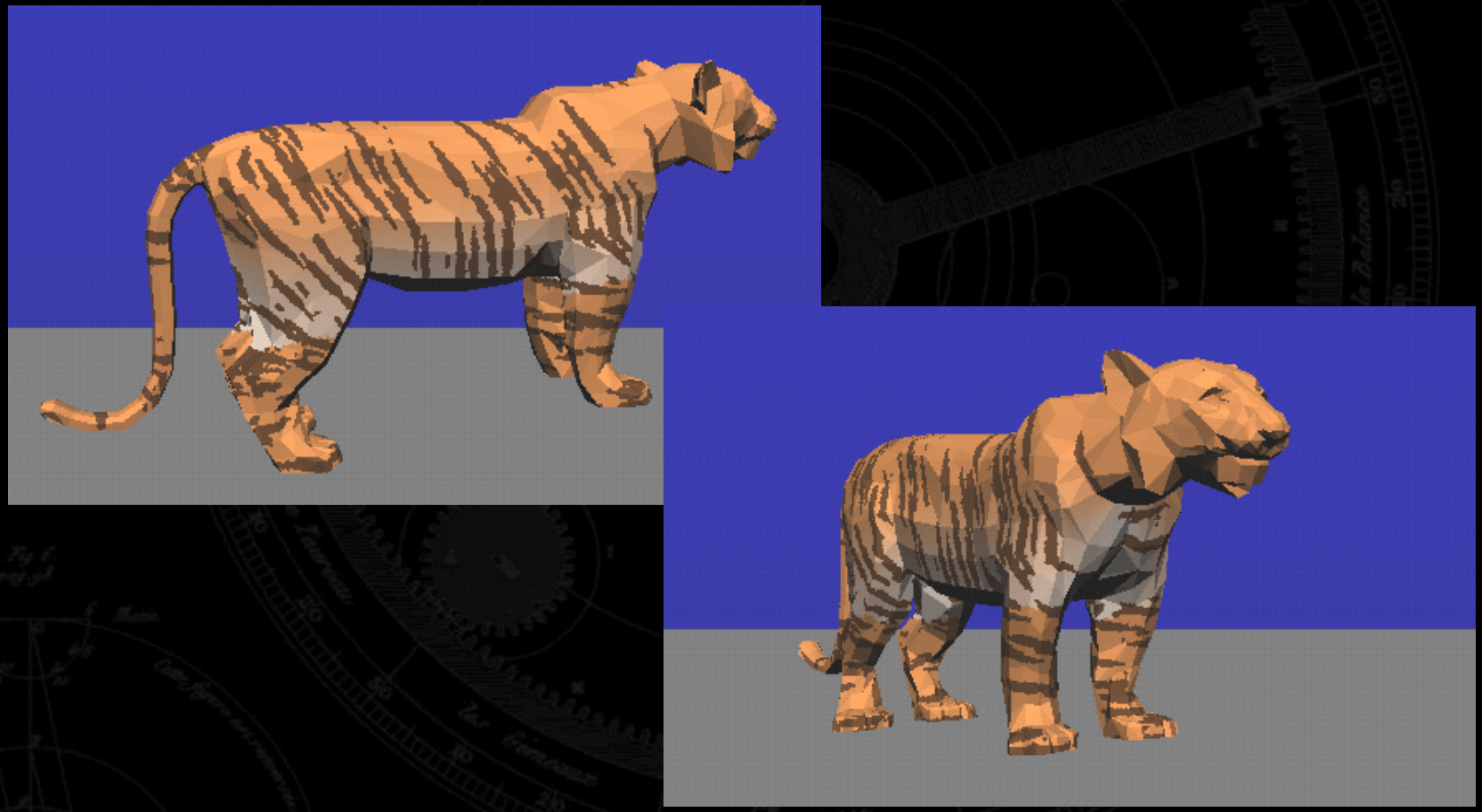
Control of Parameters

Use the cylinders to control parameters, e.g:

- To prevent areas of the body to receive pattern
- Spots of different sizes in different areas of the body

Special patterns (such as face)

Control of Parameters

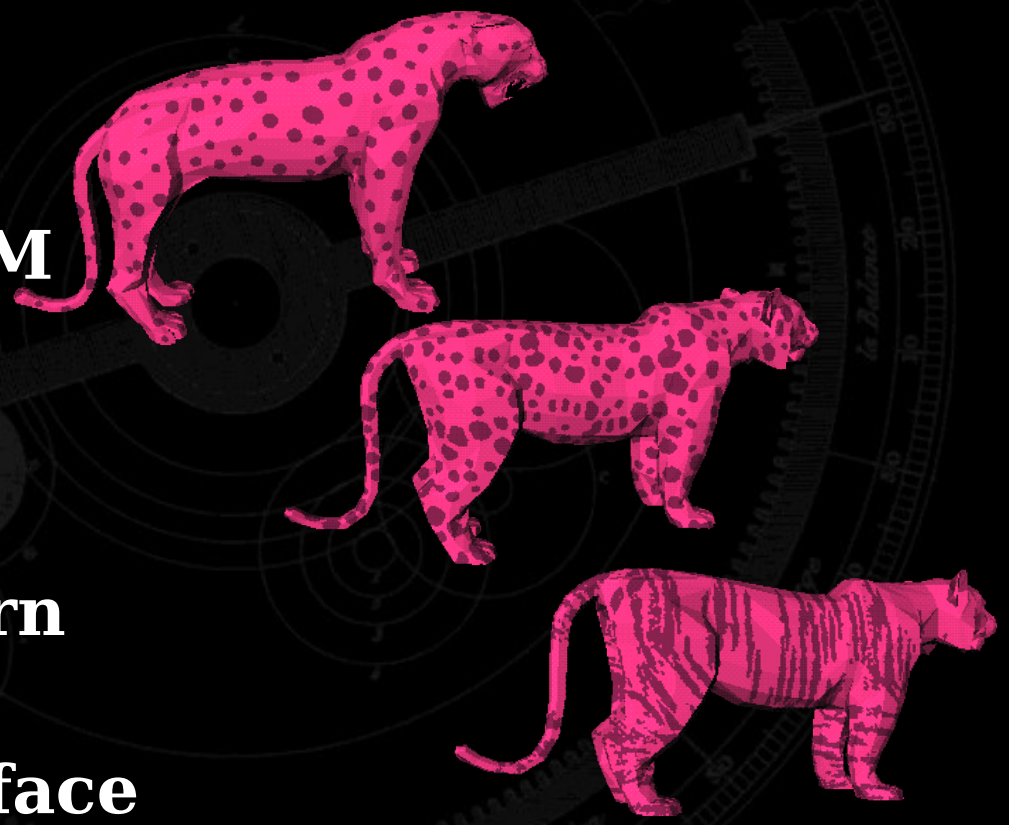


Conclusions

- Approach that integrates a biologically-plausible pattern generation model with a body growth and animation system
- Enables the automatic generation of individual bodies and their associated patterns

Future Work

- Exploration of CM patterns
- CM modeling of other phenomena
- Shape and Pattern Morphing
- Details, such as face



Thank you

To Alain Fournier, for his guidance, support, knowledge, and inspiration.